US008248921B2

(12) United States Patent
Yuan et al.

(10) Patent No.: US 8,248,921 B2
(45) Date of Patent: Aug. 21, 2012

(54) SYSTEM AND METHOD OF DISTRIBUTING DIGITAL CONTENT

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1160 days.

(21) Appl. No.: **11/592,706**

(22) Filed: **Nov. 3, 2006**

(65) **Prior Publication Data**

US 2008/0107017 A1 May 8, 2008

(51) **Int. Cl.**
G01R 31/08 (2006.01)

(52) **U.S. Cl.** **370/222**

(58) **Field of Classification Search** .... None
See application file for complete search history.

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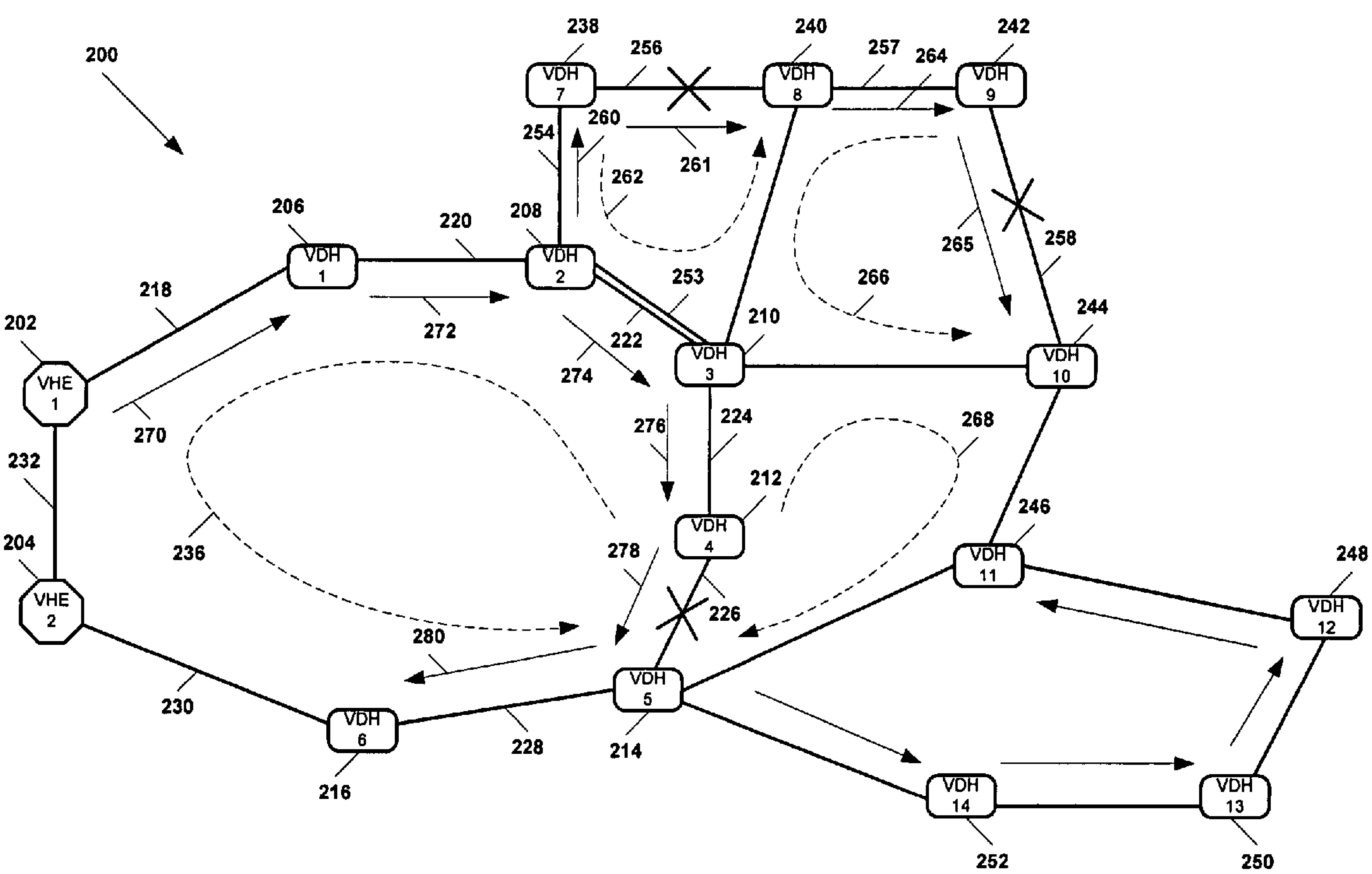
(57) **ABSTRACT**

A method is disclosed that includes receiving a data packet at a first video distribution hub via a first link. The method also includes determining whether a second link has failed, wherein the first video distribution hub communicates with a second video distribution hub via a primary network path that includes the second link. When the second link has failed, a backup network path to send the data packet, or a copy thereof, to the second video distribution hub, is determined based on data stored at the first video distribution hub. The method also includes sending the data packet, or the copy thereof, to the second video distribution hub via the backup network path, wherein the backup network path does not include the second link.

25 Claims, 6 Drawing Sheets



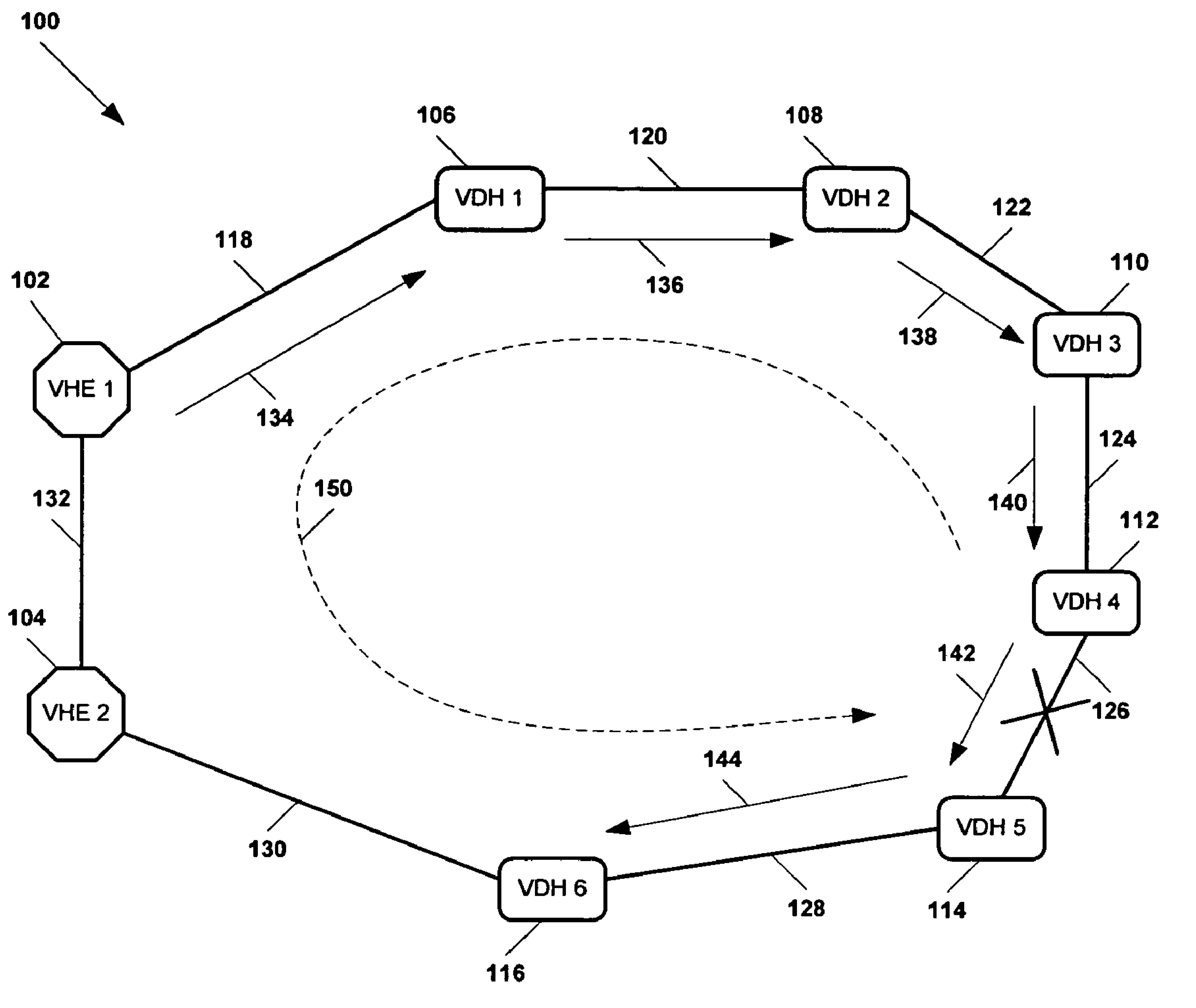

100
106
120
108
VDH 1
VDH 2
122
118
136
110
102
138
VDH 3
VHE 1
134
124
150
140
132
112
VDH 4
104
142
126
VHE 2
144
VDH 5
130
VDH 6
128
114
116

FIG. 1

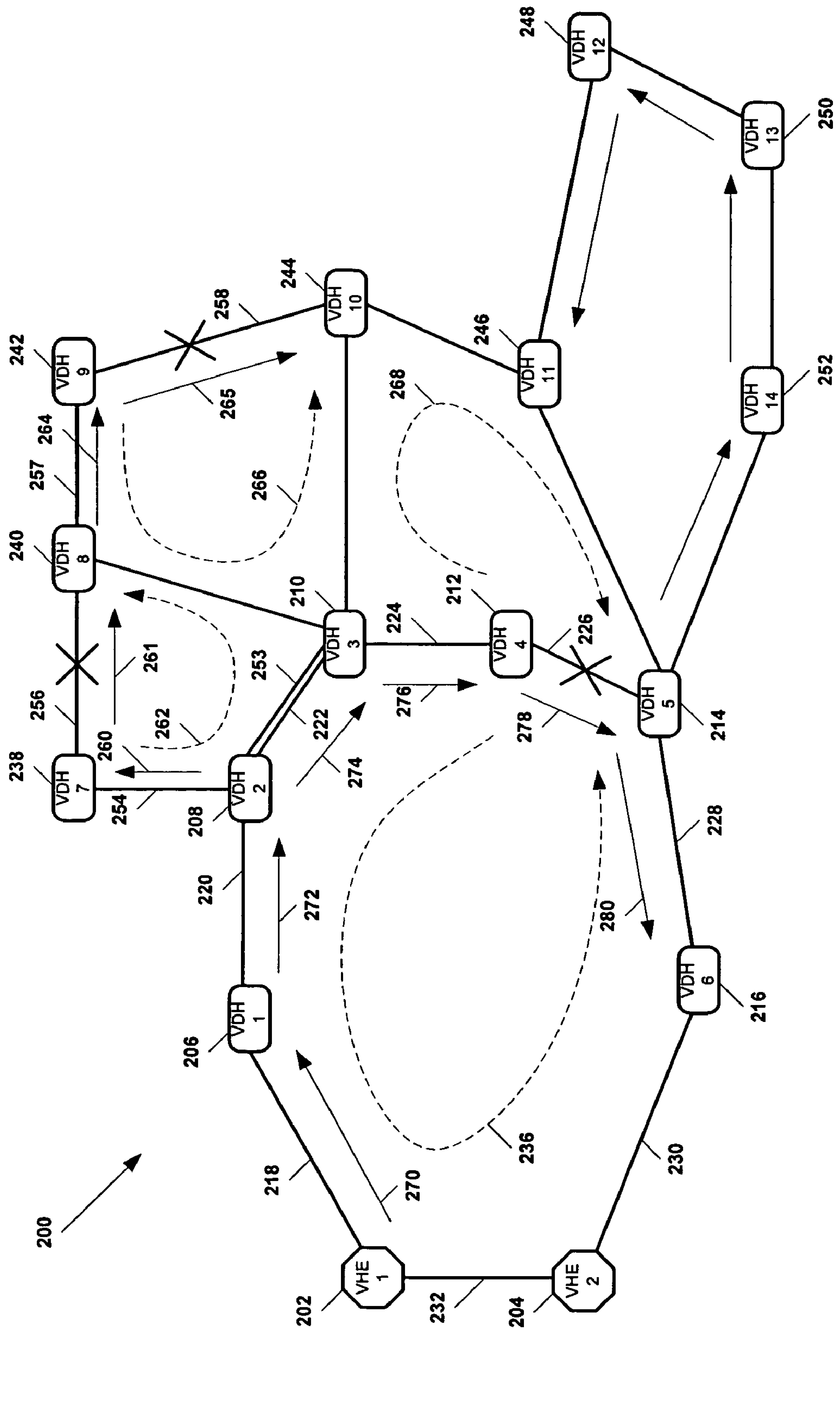
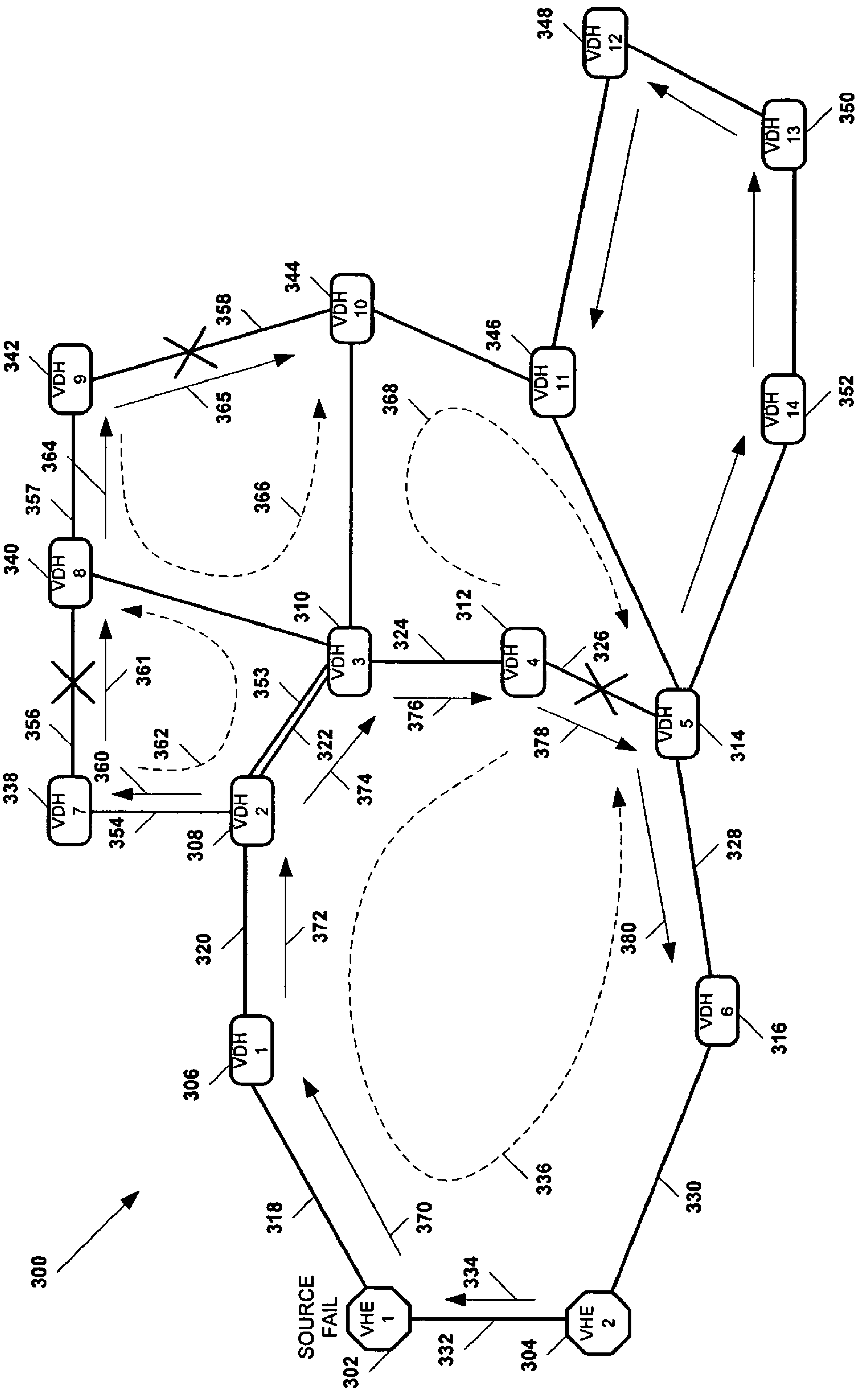

200
VHE 1
VHE 2
VDH 1
VDH 2
VDH 3
VDH 4
VDH 5
VDH 6
VDH 7
VDH 8
VDH 9
VDH 10
VDH 11
VDH 12
VDH 13
VDH 14
202
204
206
208
210
212
214
216
218
220
222
224
226
228
230
232
236
238
240
242
244
246
248
250
252
253
254
256
257
258
260
261
262
264
265
266
268
270
272
274
276
278
280

FIG. 2


300
VHE 1
VHE 2
SOURCE FAIL
302
304
332
334
318
370
330
336
VDH 1
VDH 2
VDH 3
VDH 4
VDH 5
VDH 6
VDH 7
VDH 8
VDH 9
VDH 10
VDH 11
VDH 12
VDH 13
VDH 14
306
308
310
312
314
316
320
322
324
326
328
338
340
342
344
346
348
350
352
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360
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362
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365
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368
372
374
376
378
380

FIG. 3

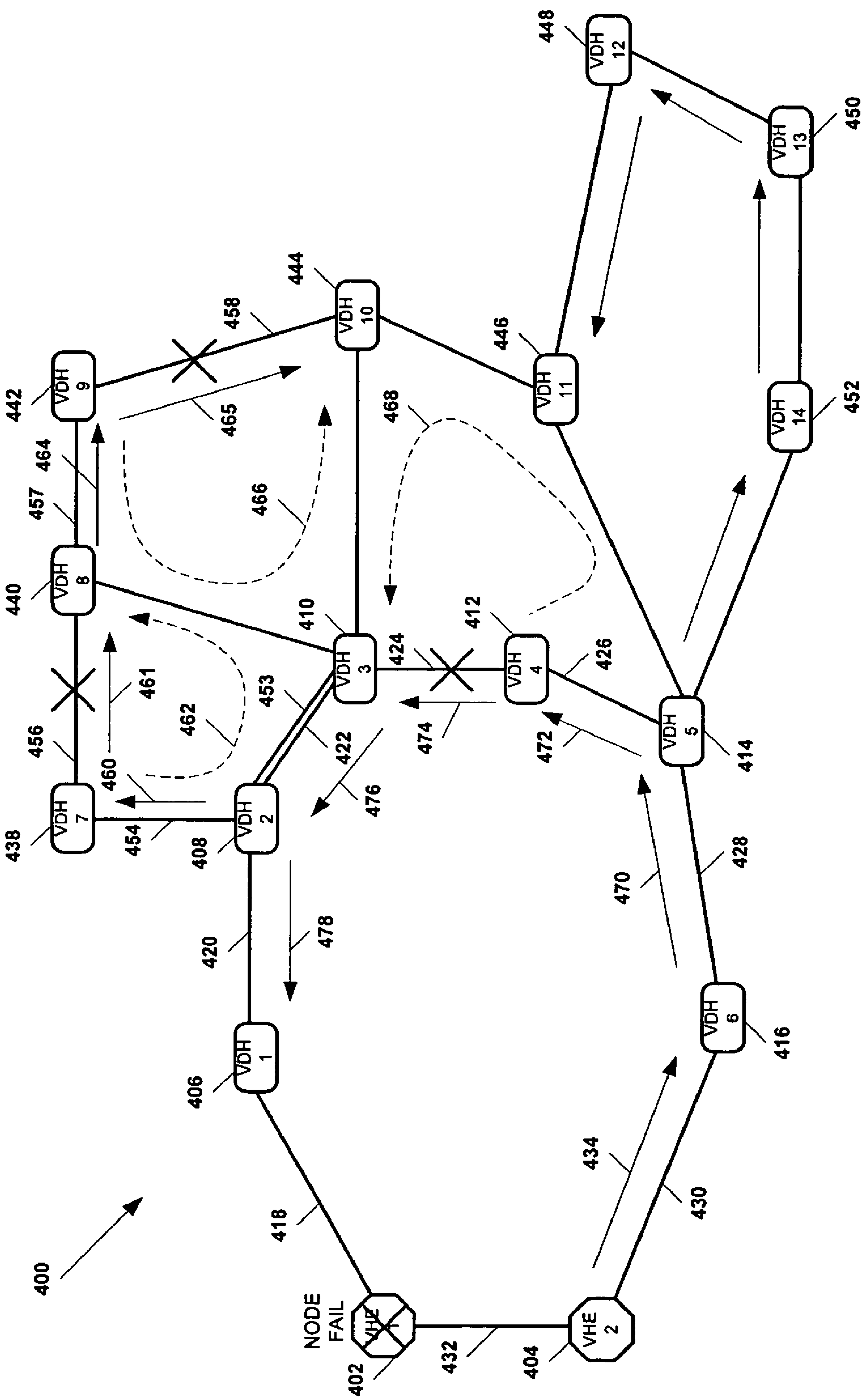
400
NODE FAIL
VHE 1
402
432
VHE 2
404
418
430
434
VDH 1
406
420
478
VDH 2
408
454
VDH 7
438
460
456
461
462
VDH 8
440
457
464
VDH 9
442
465
458
VDH 10
444
466
453
422
476
VDH 3
410
424
474
VDH 4
412
472
426
468
VDH 5
414
428
470
VDH 6
416
VDH 11
446
VDH 12
448
VDH 13
450
VDH 14
452

FIG. 4

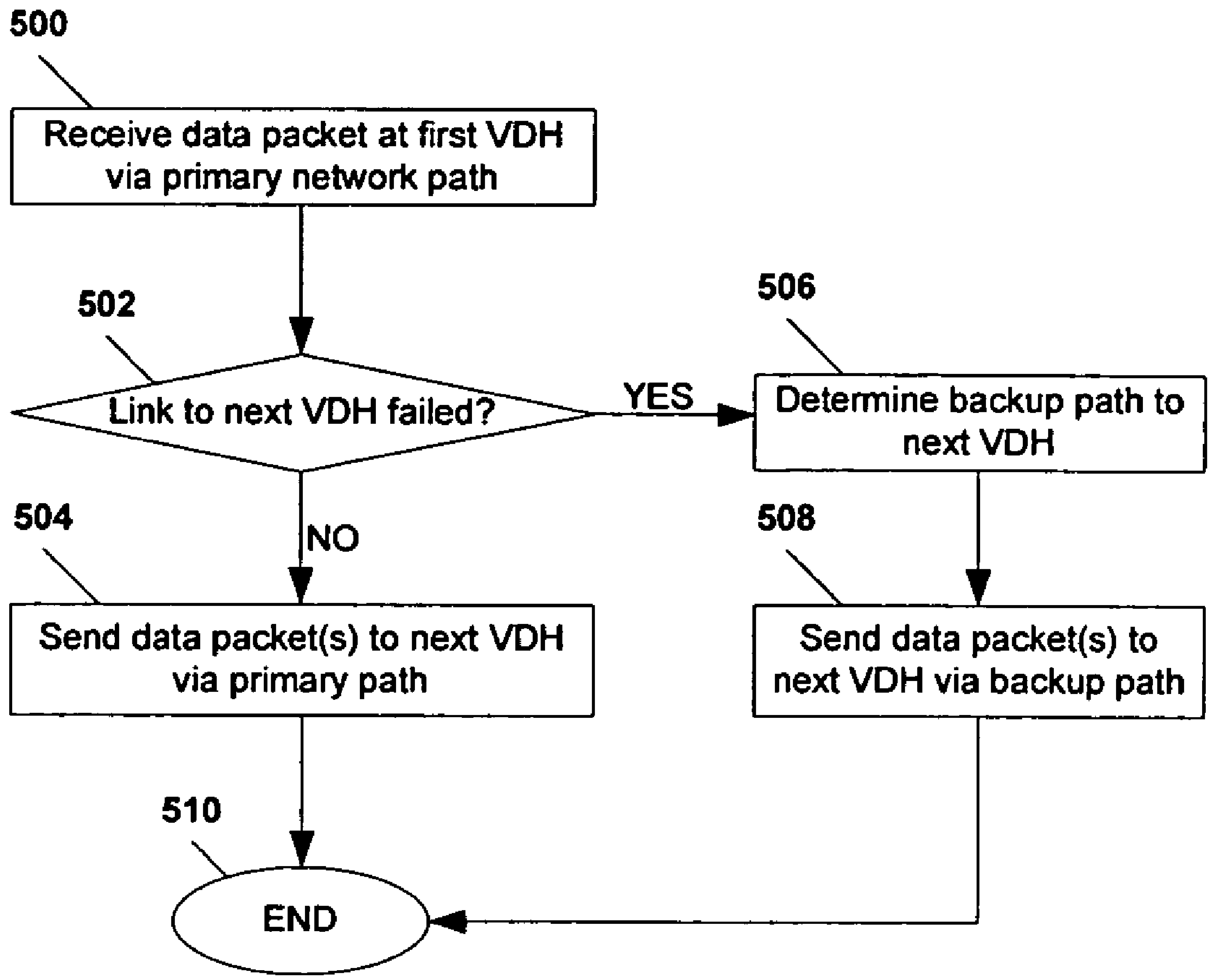
500
Receive data packet at first VDH via primary network path
502
Link to next VDH failed?
YES
506
Determine backup path to next VDH
NO
504
Send data packet(s) to next VDH via primary path
508
Send data packet(s) to next VDH via backup path
510
END

FIG. 5

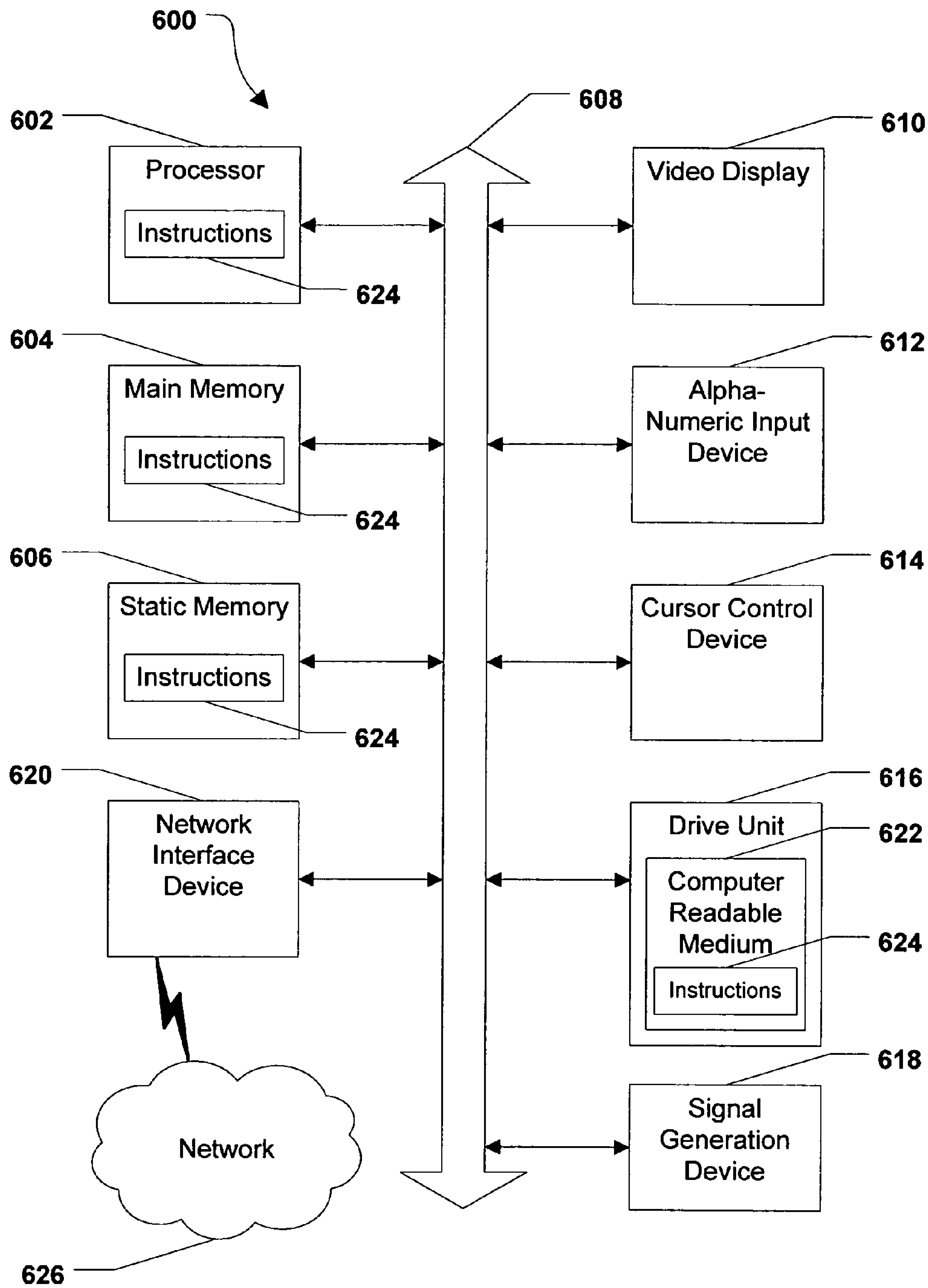
600
602
Processor
Instructions
624
604
Main Memory
Instructions
624
606
Static Memory
Instructions
624
620
Network Interface Device
Network
626
608
610
Video Display
612
Alpha-Numeric Input Device
614
Cursor Control Device
616
Drive Unit
622
Computer Readable Medium
624
Instructions
618
Signal Generation Device

FIG. 6

SYSTEM AND METHOD OF DISTRIBUTING DIGITAL CONTENT

FIELD OF THE DISCLOSURE

The present disclosure relates generally to distributing digital content.

BACKGROUND

Communication service providers can provide communications services to multiple households simultaneously. As service areas become larger, additional infrastructure is typically employed. If a device or connection in such infrastructure fails, however, distributing content to the rest of the network may depend on identifying and repairing the failure, re-generating data packets at a head-end device, or other solutions that may result in congestion or other delays in data traffic. Hence, there is a need for an improved system and method of distributing digital content.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a particular illustrative embodiment of a system to distribute digital content;

FIG. **2** is a block diagram of a second particular illustrative embodiment of a system to distribute digital content;

FIG. **3** is a block diagram of a third particular illustrative embodiment of a system to distribute digital content;

FIG. **4** is a block diagram of a fourth particular illustrative embodiment of a system to distribute digital content;

FIG. **5** is a flow diagram of a particular illustrative embodiment of a method of distributing digital content; and

FIG. **6** is a diagram of an illustrative embodiment of a general computer system.

DETAILED DESCRIPTION OF THE DRAWINGS

A system to distribute digital content is disclosed and includes a first video distribution hub coupled to a first link and coupled to a second link. The first video distribution hub is adapted to receive a data packet via the first link and to communicate the data packet, or a copy thereof, to a second video distribution hub via a primary network path that includes the second link when the second link has not failed. The first video distribution hub is adapted to communicate the data packet, or a copy thereof to the second video distribution hub via a backup network path that does not include the second link when the second link has failed. The backup network path is determined based on data stored at the first video distribution hub.

In a particular embodiment, the backup network path can be viewed as an alternative route from the first distribution hub to the second distribution hub and is only used when the second link has failed. Each physical link between any two adjacent distribution hubs has one primary network path but at least one alternative backup network path.

In another particular embodiment, a method of distributing digital content is disclosed and includes receiving a data packet at a first video distribution hub via a first link. The method also includes determining whether a second link has failed, wherein the first video distribution hub communicates with a second video distribution hub via a primary network path that includes the second link. When the second link has failed, a backup network path to send the data packet, or a copy thereof, to the second video distribution hub, is determined based on data stored at the first video distribution hub.

The method also includes sending the data packet, or the copy thereof, to the second video distribution hub via the backup network path, wherein the backup network path does not include the second link.

In another particular embodiment, a computer-readable medium is disclosed and includes instructions executable to determine whether a link between a first video distribution hub and a second video distribution hub has failed, where the first distribution hub communicates with the second distribution hub via a primary network path that includes the link. The computer-readable medium also includes instructions to determine, when the second link has failed, a backup network path to send a data packet from the first video distribution hub to the second video distribution hub, the backup network path determined based on data stored at the first video distribution hub. The computer-readable medium also includes instructions to send the data packet to the second video distribution hub via the backup network path, wherein the backup network path does not include the link.

In another particular embodiment, a network is disclosed and includes a plurality of nodes including a first video distribution hub and a second video distribution hub, where the plurality of nodes are connected via Multi-Protocol Packet Label Switching (MPLS) links to form at least one network ring. A data packet including video content is routed from the first video distribution hub to the second video distribution hub via a primary network path when a MPLS link connecting the first video distribution hub to the second video distribution hub has not failed. The data packet is re-routed from the first video distribution hub to the second video distribution hub via a backup network path that does not include the MPLS link when the MPLS link has failed, the backup network path pre-defined at the first video distribution hub.

Referring to FIG. **1**, a particular illustrative embodiment of a system to distribute digital content is illustrated and designated generally at **100**. The system **100** includes a first video head-end (VHE) **102** that communicates with a video content source via a satellite system or other broadcast or data system. In a particular embodiment, the system **100** can include a second VHE **104**, such as a back-up VHE, which also communicates with the video content source. The system **100** also includes a plurality of video distribution hubs (VDHs) **106-116** that are adapted to receive data packets, or copies of data packets, from the video head-ends **102**, **104**. In an illustrative embodiment, each of the VHEs and VDHs can include one or more devices, such as one or more servers, switches, routers, or other devices, where each device can be adapted to perform one or more of the functions of the VHE or VDH with respect to distributing digital content, such as receiving a data packet, sending a data packet, storing data, determining a network path, and other functions.

In a particular embodiment, the first VHE **102** and second VHE **104** can be adapted to communicate video content with user communications devices via the plurality of VDHs **106-116**. For example, the first VHE **102** and second VHE **104** can be adapted to communicate multicast video content of an Internet Protocol Television (IPTV) system to set-top box devices via the VDHs **106-116**. In another particular embodiment, other content, such as voice content, data content, or any combination thereof, can be transmitted via the VDHs **106-116** to other user devices, such as Voice-over Internet Protocol (VoIP) phones, computing devices, other devices, or any combination thereof. In an illustrative embodiment, the first VHE **102** and the second VHE **104** can provide digital content over a national network, where the plurality of VDHs **106-116** serve a plurality of regions. In another embodiment, the first VHE **102** and the second VHE **104** can provide digital content over a regional network, where the plurality of VDHs **106-116** serve a plurality of neighborhoods or other sub-regions.

The first VHE **102**, the second VHE **104**, and the plurality of VDHs **106-116**, comprise nodes of a network ring topology or similar architecture. Network ring topologies can be advantageous because they can minimize the number of copies of broadcast or multicast video content sent from the first VHE **102** or the second VHE **104**. Hence, the required bandwidth of the network may be reduced. For example, the first VHE **102** can send one copy of a data packet, and the copy can be propagated along the ring via the primary network paths **134-144**, or backup network paths including the backup network path **150**, such that all VDHs **106-116** on the ring will receive the copy. In a particular embodiment, the network topology or architecture can include multiple cascaded rings, where additional rings receive copies of a data packet from one or more of the plurality of VDHs **106-116**. Examples of cascaded ring topologies are illustrated in FIGS. **2-4**.

As illustrated in FIG. **1**, the various nodes **102-116** of the ring are connected via a plurality of links **118-132**. For example, the first VHE **102** can communicate with a first VDH **106** via a first link **118**. In addition, the first VDH **106** can communicate with a second VDH **108** via a second link **120**. Further, the second VDH **108** can communicate with a third VDH **110** via a third link **122**. The third VDH **110** can communicate with a fourth VDH **112** via a fourth link **124**, and so on. Moreover, the first VHE **102** can communicate with the second VHE **104** via another link **132**.

In a particular embodiment, each of the links **118-132** can be a Multi-Protocol Label Switching (MPLS) link. MPLS technology can provide fast restoration (~50 milliseconds) for link failures via its path protection mechanism, which can be advantageous for multicast video and other real-time content. In addition, the MPLS path protection is operated on the logical level and can often eliminate the need for physical layer protection. In a network ring topology, for example, MPLS path protection is conducted by re-routing data packets in the opposite direction of normal traffic flow. Thus, additional links are not typically required, as when path protection is performed at the physical level.

With respect to each link between two adjacent nodes of the ring, there is a single primary network path that is coincident with the link. The primary network path begins at a VHE or a VDH sending the packet and ends at the next VDH receiving the packet along the ring. For example, the primary network path **142** that corresponds to the link **126** begins at the fourth VDH **112** and ends at the fifth VDH **114**. The primary network paths **134-144** follow a same direction, such as clockwise or counterclockwise along the ring. In a particular embodiment, a link cost of IP routing can be assigned to each physical link, thereby causing packet forwarding to follow a preferred direction along the ring.

For example, a data packet may travel to the fifth VDH **114** via links **132-130-128**, even in the absence of a link failure among physical links **118-126**, if all physical links **118-132** have equal link costs. Link costs of physical links **128**, **130**, **132**, or any combination thereof, can be assigned such that a data packet will be sent to the fifth VDH **114** via the primary network paths **134-142** through physical links **118-126**, in the absence of a link failure in links **118-126**, even though this is not the route with the least number of hops between adjacent nodes. In an illustrative embodiment, a cost of routing a data packet via a particular physical link can be assigned as a function of bandwidth or any artificial number, such that sending data packets via the primary paths **134-142** will appear more efficient or otherwise more optimal to an IP router, in absence of a link failure, than sending the data packets via another route.

When a link fails, traffic is re-routed via at least one predetermined backup network path. Each backup network path has the same beginning point and ending point as the corresponding primary network path but traverses in a direction opposite to the primary network path along the ring. For example, in the embodiment illustrated in FIG. **1**, the backup network path **150** for link **126** begins at the fourth VDH **112** and ends at the fifth VDH **114**, similar to the primary network path **142**. Nonetheless, traffic along the backup network path **150** flows in a direction that is opposite to that of the primary network path **142**. In an illustrative embodiment, the backup network path of each physical link can be statically predetermined such that it traverses in the reverse direction of the primary network path. In another embodiment, the backup network path can be dynamically constructed through IP routing in a simple topology, for example a single ring.

In an illustrative embodiment, each link can include a plurality of fiber optics lines (sometimes referred to herein as "fiber cables"). For example, each link can include a first fiber cable and a second fiber cable, where each first fiber cable transmits data via a primary network path and each second fiber cable transmits data via a backup path that is the reverse of the primary network path. For instance, a first fiber cable of the fourth link **124** can transmit data downstream from the third VDH **110** to the fourth VDH **112**, and a second fiber cable of the fourth link **124** can carry data upstream from the fourth VDH **112** to the third VDH **110**. The ring topology can take advantage of the asymmetric nature of typical broadcast and multicast video content (i.e., downstream traffic from the video source is much bigger than upstream traffic) to improve the efficiency of bandwidth utilization on network links. For instance, re-routed traffic sent via the backup network path **150** due to a failure of the fifth link **126** can flow over the second (upstream) fiber cable of the fourth link **124** (and upstream fiber cables of links **122**, **120**, and so on) in a direction opposite to that of the primary network path **142**.

In a particular illustrative embodiment, the first VHE **102** can receive video content from a content source via a satellite system. The first VHE **102** can send one or more data packets carrying the video content to the plurality of VDHs **106-116** via the links **118-128**. For example, the first VHE **102** can send a data packet to the first VDH **106** via the first link **118**. The first VDH **106** can send copies of the data packet to devices within its region or sub-region and send the data packet to the second VDH **108** via the second link **120**. Thus, in an illustrative embodiment, a single copy of the data packet can be propagated through the plurality of VDHs **106-116** via the primary network paths **134-144**.

In a particular embodiment, a link between two of the plurality of VDHs can fail due to physical damage, power failure or other failure condition. For example, the fifth link **126** between the fourth VDH **112** and the fifth VDH **114** can fail. The fourth VDH **112** can detect the link failure and determine that the primary network path **142** cannot be used to route the data packet to the fifth VDH **114**. The fourth VDH **112** can determine, based on data stored at the fourth VDH **112**, that a backup network path **150** that does not include the fifth link **126** will be used to send the data packet to the fifth VDH **114**. The data stored at the fourth VDH **112** can indicate that the backup network path **150** is a pre-defined alternate to the primary network path **142** and flows in a direction opposite to the direction of the primary network path **142**. In an illustrative embodiment, the primary network path **142** can include a downstream fiber cable of the fifth link **126**, whereas the backup network path **150** can include an upstream fiber cable of the fourth link **124** and upstream fiber cables of the links **118-122** and **128-132**.

Referring to FIG. **2**, a second particular embodiment of a system to distribute digital content is illustrated and designated generally at **200**. The system **200** includes a first video head-end (VHE) **202** that communicates with a video content source via a satellite system or other broadcast or data system. In a particular embodiment, the system **200** can include a second VHE **204**, such as a back-up VHE, which also communicates with the video content source. The system **200** also includes a plurality of video distribution hubs (VDHs) **206-216** and **238-252**, which are adapted to receive data packets, or copies of data packets, from the video head-ends **202**, **204**. In an illustrative embodiment, each of the VHEs and VDHs can include one or more devices, such as one or more servers, switches, routers, or other devices, where each device can be adapted to perform one or more of the functions of the VHE or VDH with respect to distributing digital content, such as receiving a data packet, sending a data packet, storing data, determining a network path, and other functions.

In a particular embodiment, the first VHE **202** and second VHE **204** can be adapted to communicate video content with user communications devices via the plurality of VDHs **206-216** and **238-252**. For example, the first VHE **202** and second VHE **204** can be adapted to communicate multicast video content of an Internet Protocol Television (IPTV) system, to set-top box devices via the VDHs **206-216** and **238-252**. In another particular embodiment, other content, such as voice content, data content, or any combination thereof, can be transmitted via the VDHs **206-216** and **238-252** to other user devices, such as Voice-over Internet Protocol (VoIP) phones, computing devices, other devices, or any combination thereof. In an illustrative embodiment, the first VHE **202** and the second VHE **204** can provide digital content over a national network, where the plurality of VDHs **206-216** and **238-252** serve a plurality of regions. In another embodiment, the first VHE **202** and the second VHE **204** can provide digital content over a regional network, where the plurality of VDHs **206-216** and **238-252** serve a plurality of neighborhoods or other sub-regions.

The first VHE **202**, the second VHE **204**, and the plurality of VDHs **206-216** and **238-252** comprise nodes of a cascaded network ring topology or similar architecture, in which a copy of a data packet sent by the first VHE **202** or the second VHE **204** is propagated through the plurality of VDHs **206-216** and **238-252** via multiple ring-like network architectures, where at least two of the rings share one or more common VDHs or other nodes, as well as the links of overlapped segments.

As illustrated in FIG. **2**, the various nodes of the cascaded ring topology are connected via a plurality of links **218-232** and **253-258**. For example, the first VHE **202** can communicate with a first VDH **206** via a first link **218**. In addition, the first VDH **206** can communicate with a second VDH **208** via a second link **220**. Further, the second VDH **208** can communicate with a third VDH **210** via a third link **222**. In an illustrative embodiment, the second VDH **208** can also communicate with a seventh VDH **238**, within a second ring of the cascaded ring architecture, via another link **254**. In a particular embodiment, each of the links **218-232** and **253-258** is a Multi-Protocol Label Switching (MPLS) link.

In the example illustrated in FIG. **2**, double links, such as links with double bandwidth, double physical links, or any combination thereof, can be included between the second VDH **208** and the third VDH **210** to allow re-routing of data packets along the backup network path **262**, to prevent congestion in transmission of packets within this overlapped segment caused by re-routing of packets in the second network ring, for other reasons, or any combination thereof.

In an exemplary embodiment, the cascaded ring topology illustrated in FIG. **2** can be designed such that the directions of primary network paths in each individual ring minimize the need for double bandwidth on overlapped segments between two adjacent rings. Not only the quantity but also the length of overlapped segments can be minimized to reduce the capital cost of establishing the rings. For example, the cascaded ring topology can be designed such that directions of primary network paths in two adjacent rings are opposite wherever possible, in order to reduce double bandwidth requirements for overlapped segments.

In a particular illustrative embodiment, the first VHE **202** can receive video content from a content source. The first VHE **202** can send one or more data packets carrying the video content to the plurality of VDHs **206-216** in a first network ring via the links **218-228**. For example, the first VHE **202** can send a data packet to the first VDH **206** via the first link **218**. The first VDH **206** can send copies of the data packet to devices within its region or sub-region and send the data packet to the second VDH **208** via the second link **220**. Thus, in an illustrative embodiment, a single copy of the data packet can be propagated through the VDHs **206-216** via the primary network paths **270-280**.

In an exemplary embodiment, the second VDH **208** can send a copy of the data packet to the seventh VDH **238**, which is a part of a second network ring, via another link **254**. Further, the seventh VDH **238** can send copies of the data packet to devices within its region or sub-region and send the data packet to an eighth VDH **240** via a next link **256**. Thus, in an illustrative embodiment, a copy of the data packet can be propagated through the VDHs **238-240** via the primary network paths **260-261** that are associated with the second network ring. In addition, a copy of the data packet can be propagated through the VDHs **242-244** via the primary network paths **264-265** that are associated with the third network ring. As illustrated in FIG. **2**, a copy of the data packet can be propagated through additional network rings.

In a particular embodiment, a link between two VDHs can fail. For example, the fifth link **226** between the fourth VDH **212** and the fifth VDH **214** can fail. The fourth VDH **212** can detect the link failure and determine that the primary network path **278** cannot be used to route the data packet to the fifth VDH **214**. The fourth VDH **212** can determine, based on data stored at the fourth VDH **212**, that a backup network path **236** that does not include the fifth link **226** will be used to send the data packet to the fifth VDH **214**. The data stored at the fourth VDH **212** can indicate that the backup network path **236** is a pre-defined alternate to the primary network path **278** and flows in a direction opposite to the direction of the primary network path **278**. In an illustrative embodiment, the primary network path **278** can include a downstream fiber cable of the fifth link **226**, whereas the backup network path **236** can include an upstream fiber cable of the fourth link **224** and upstream fiber cables of the links **218-222** and **228-232**.

Alternatively, the fourth VDH **212** can determine, based on data stored at the fourth VDH **212**, that the data packet, or a copy thereof, should be re-routed to the fifth VDH **214** via a secondary backup network path **268** associated with another network ring of which the fourth VDH **212** and fifth VDH **214** are nodes. For instance, the data stored at the fourth VDH **212** can indicate that the first backup network path **236** and the second backup network path **268** are alternates to the primary network path **278**, and the fourth VDH **212** can select one of them based on traffic volume, available bandwidth, link cost, other factors, or any combination thereof.

In an illustrative, non-limiting example, the fourth VDH **212** can store the data as a look-up table that associates paths by which a data packet is received with one or more alternate paths to the fifth VDH **214**. Where multiple alternate network paths are possible, such as the backup network path **236** and the second backup network path **268**, the fourth VDH **212** can include logic to select one of the alternate network paths, for example, based on data traffic/bandwidth available for each alternate network path, a number of hops (i.e., between pairs of nodes) associated with each alternate network path, transmission speed of each alternate network path, other factors, or any combination thereof.

In another example, a link **256** between the seventh VDH **238** and the eighth VDH **240** can fail. The seventh VDH **238** can detect the link failure and determine that the primary network path **261** cannot be used to route the data packet to the eighth VDH **240**. The seventh VDH **238** can determine, based on data stored at the seventh VDH **238**, that a backup network path **262** that does not include the failed link **256** will be used to send the data packet to the eighth VDH **240**. The data stored at the seventh VDH **238** can indicate that the backup network path **262** is a pre-defined alternate to the primary network path **261** and flows in a direction opposite to the direction of the primary network path **261**. In an illustrative embodiment, the primary network path **261** can include a downstream fiber cable of the failed link **256**, whereas the backup network path **262** can include an upstream fiber cable of the link **254** and can include link **253** of the double link between the second VDH **208** and the third VDH **210**.

In another example, a link **258** between the ninth VDH **242** and the tenth VDH **244** can fail. The ninth VDH **242** can detect the link failure and determine that the primary network path **265** cannot be used to route the data packet to the tenth VDH **244**. The ninth VDH **242** can determine, based on data stored at the ninth VDH **242**, that a backup network path **266** that does not include the failed link **258** will be used to send the data packet to the tenth VDH **244**. The data stored at the ninth VDH **242** can indicate that the backup network path **266** is a pre-defined alternate to the primary network path **265** and flows in a direction opposite to the direction of the primary network path **265**. In an illustrative embodiment, the primary network path **265** can include a downstream fiber cable of the failed link **258**, whereas the backup network path **266** can include an upstream fiber cable of the link **257**.

Referring to FIG. **3**, a third particular embodiment of a system to distribute digital content is illustrated and designated generally at **300**. The system **300** includes a first video head-end (VHE) **302** that communicates with a video content source and a second VHE **304** that also communicates with the video content source. The system **300** also includes a plurality of video distribution hubs (VDHs) **306-316** and **338-352**, which are adapted to receive data packets, or copies of data packets, from the video head-ends **302**, **304**.

In a particular embodiment, the first VHE **302** and second VHE **304** can be adapted to communicate video content with user communications devices via the plurality of VDHs **306-316** and **338-352**. For example, the first VHE **302** and second VHE **304** can be adapted to communicate multicast video content of an Internet Protocol Television (IPTV) system, to set-top box devices via the VDHs **306-316** and **338-352**. In another particular embodiment, other content, such as voice content, data content, or any combination thereof, can be transmitted via the VDHs to other user devices, such as Voice-over Internet Protocol (VoIP) phones, computing devices, other devices, or any combination thereof. In an illustrative embodiment, the first VHE **302** and the second VHE **304** can provide digital content over a national network, where the plurality of VDHs **306-316** and **338-352** serve a plurality of regions. In another embodiment, the first VHE **302** and the second VHE **304** can provide digital content over a regional network, where the plurality of VDHs **306-316** and **338-352** serve a plurality of neighborhoods or other sub-regions.

The first VHE **302**, the second VHE **304**, and the plurality of VDHs **306-316** and **338-352** comprise nodes of a cascaded network ring topology or similar architecture, in which a copy of a data packet sent by the first VHE **302** or the second VHE **304** is propagated through the plurality of VDHs **306-316** and **338-352** via multiple ring-like network architectures, where at least two of the rings share one or more common VDHs or other nodes, as well as the links of overlapped segments.

As illustrated in FIG. **3**, the various nodes of the cascaded ring topology are connected via a plurality of links **318-332** and **353-358**. For example, the first VHE **302** can communicate with a first VDH **306** via a first link **318**. In addition, the first VDH **306** can communicate with a second VDH **308** via a second link **320**. Further, the second VDH **308** can communicate with a third VDH **310** via a third link **322**. In an illustrative embodiment, the second VDH **308** can also communicate with a seventh VDH **338**, within a second ring of the cascaded ring architecture, via another link **354**. In a particular embodiment, each of the links **318-332** and **353-358** is a Multi-Protocol Label Switching (MPLS) link.

In a particular illustrative embodiment, the first VHE **302** can cease receiving video content from a content source, for example, due to loss of connection with, or failure of, a satellite system or other receiving system at the first VHE **302**. However, it can still pass data traffic received from the second VHE **304** and from the first VDH **306**. In this embodiment, the second VHE **304** can receive the video content from the content source or an alternate content source and can send one or more data packets carrying the video content to the plurality of VDHs **306-316** in a first network ring via the links **332** and **318-328**. For example, the second VHE **304** can send a data packet to the first VHE **302** via the link **332**, and the first VHE **304** can send the data packet to the first VDH **306** via the link **318**. The first VDH **306** can send copies of the data packet to devices within its region or sub-region and send the data packet to the second VDH **308** via a next link **320**. Thus, in an illustrative embodiment, a single copy of the data packet sent by the second VHE **304** can be propagated through the VDHs **306-316** via the primary network paths **334** and **370-380** in the first network ring.

In an exemplary embodiment, the second VDH **308** can send a copy of the data packet to the seventh VDH **338**, which is a part of a second network ring, via another link **354**. Further, the seventh VDH **338** can send copies of the data packet to devices within its region or sub-region and send the data packet to an eighth VDH **340** via a next link **356**. Thus, in an illustrative embodiment, a copy of the data packet can be propagated through the VDHs **338-340** via the primary network paths **360-361** that is associated with the second network ring. In addition, a copy of the data packet can be propagated through the VDHs **342-344** via the primary network paths **364-365** that is associated with the third network ring.

In a particular embodiment, a link between two VDHs can fail. For example, the fifth link **326** between the fourth VDH **312** and the fifth VDH **314** can fail. The fourth VDH **312** can detect the link failure and determine that the primary network path **378** cannot be used to route the data packet to the fifth VDH **314**. The fourth VDH **312** can determine, based on data stored at the fourth VDH **312**, that a backup network path **336** that does not include the fifth link **326** will be used to send the data packet to the fifth VDH **314**. The data stored at the fourth

VDH **312** can indicate that the backup network path **336** is a pre-defined alternate to the primary network path **378** and flows in a direction opposite to the direction of the primary network path **378**. In an illustrative embodiment, the primary network path **378** can include a downstream fiber cable of the fifth link **326**, whereas the backup network path **336** can include an upstream fiber cable of the fourth link **324** and upstream fiber cables of the links **318-322** and **328-332**.

Alternatively, the fourth VDH **312** can determine, based on data stored at the fourth VDH **312**, that the data packet, or a copy thereof, should be re-routed to the fifth VDH **314** via a secondary backup network path **368** associated with another network ring of which the fourth VDH **312** and fifth VDH **314** are nodes. For instance, the data stored at the fourth VDH **312** can indicate that the first backup network path **336** and the second backup network path **368** are alternates to the primary network path **378**, and the fourth VDH **312** can select one of them based on traffic volume, available bandwidth, link cost, other factors, or any combination thereof.

In an illustrative, non-limiting example, the fourth VDH **312** can store the data as a look-up table that associates paths by which a data packet is received with one or more alternate paths to the fifth VDH **314**. Where multiple alternate network paths are possible, such as the backup network path **336** and the second backup network path **368**, the fourth VDH **312** can include logic to select one of the alternate network paths, for example, based on data traffic/bandwidth available for each alternate network path, a number of hops (i.e., between pairs of nodes) associated with each alternate network path, transmission speed of each alternate network path, other factors, or any combination thereof.

In another example, a link **356** between the seventh VDH **338** and the eighth VDH **340** can fail. The seventh VDH **338** can detect the link failure and determine that the primary network path **361** cannot be used to route the data packet to the eighth VDH **340**. The seventh VDH **338** can determine, based on data stored at the seventh VDH **338**, that a backup network path **362** that does not include the failed link **356** will be used to send the data packet to the eighth VDH **340**. The data stored at the seventh VDH **338** can indicate that the backup network path **362** is a pre-defined alternate to the primary network path **361** and flows in a direction opposite to the direction of the primary network path **361**. In an illustrative embodiment, the primary network path **361** can include a downstream fiber cable of the failed link **356**, whereas the backup network path **362** can include an upstream fiber cable of the link **354** and can include link **353** of the double link between the second VDH **308** and the third VDH **310**.

In another example, a link **358** between the ninth VDH **342** and the tenth VDH **344** can fail. The ninth VDH **342** can detect the link failure and determine that the primary network path **365** cannot be used to route the data packet to the tenth VDH **344**. The ninth VDH **342** can determine, based on data stored at the ninth VDH **342**, that a backup network path **366** that does not include the failed link **358** will be used to send the data packet to the tenth VDH **344**. The data stored at the ninth VDH **342** can indicate that the backup network path **366** is a pre-defined alternate to the primary network path **365** and flows in a direction opposite to the direction of the primary network path **365**. In an illustrative embodiment, the primary network path **365** can include a downstream fiber cable of the failed link **358**, whereas the backup network path **366** can include an upstream fiber cable of the link **357**.

Referring to FIG. **4**, a third particular embodiment of a system to distribute digital content is illustrated and designated generally at **400**. The system **400** includes a first video head-end (VHE) **402** that communicates with a video content source and a second VHE **404** that also communicates with the video content source. The system **400** also includes a plurality of video distribution hubs (VDHs) **406-416** and **438-452**, which are adapted to receive data packets, or copies of data packets, from the video head-ends **402**, **404**.

In a particular embodiment, the first VHE **402** and second VHE **404** can be adapted to communicate video content with user communications devices via the plurality of VDHs **406-416** and **438-452**. For example, the first VHE **402** and second VHE **404** can be adapted to communicate multicast video content of an Internet Protocol Television (IPTV) system, to set-top box devices via the VDHs **406-416** and **438-452**. In another particular embodiment, other content, such as voice content, data content, or any combination thereof, can be transmitted via the VDHs to other user devices, such as Voice-over Internet Protocol (VoIP) phones, computing devices, other devices, or any combination thereof. In an illustrative embodiment, the first VHE **402** and the second VHE **404** can provide digital content over a national network, where the plurality of VDHs **406-416** and **438-452** serve a plurality of regions. In another embodiment, the first VHE **402** and the second VHE **404** can provide digital content over a regional network, where the plurality of VDHs **406-416** and **438-452** serve a plurality of neighborhoods or other sub-regions.

The first VHE **402**, the second VHE **404**, and the plurality of VDHs **406-416** and **438-452** comprise nodes of a cascaded network ring topology or similar architecture, in which a copy of a data packet sent by the first VHE **402** or the second VHE **404** is propagated through the plurality of VDHs **406-416** and **438-452** via multiple ring-like network architectures, where at least two of the rings share one or more common VDHs or other nodes, as well as the links of overlapped segments.

As illustrated in FIG. **4**, the various nodes of the cascaded ring topology are connected via a plurality of links **418-432** and **453-458**. For example, the first VHE **402** can communicate with a first VDH **406** via a first link **418**. In addition, the first VDH **406** can communicate with a second VDH **408** via a second link **420**. Further, the second VDH **408** can communicate with a third VDH **410** via a third link **422**. In an illustrative embodiment, the second VDH **408** can also communicate with a seventh VDH **438**, within a second ring of the cascaded ring architecture, via another link **454**. In a particular embodiment, each of the links **418-432** and **453-458** is a Multi-Protocol Label Switching (MPLS) link.

In a particular illustrative embodiment, the first VHE **402** can cease functioning as a node due to mechanical or technical difficulty, such that it cannot receive or transmit any traffic (i.e., the first VHE **402** is out of service). In this embodiment, the second VHE **404** receives video content from a content source and sends one or more data packets carrying the video content to the plurality of VDHs **406-416** in a first network ring via the primary network paths **434** and **470-478**.

In a particular embodiment, the primary network paths **434** and **470-478** can be pre-configured and are enabled through IP routing convergence after the failure of VHE **402** is detected by the network. In an illustrative embodiment, the second VHE **404** can determine that there is a node failure at the first VHE **402** and that data packets cannot be sent to the VDHs **406-416** by a network path that includes the first VHE **402**. The VHE **404** can determine based on IP routing that the data packets will be sent via an enabled primary network path **434** to the sixth VDH **416**. Hence, the second VHE **404** can send a data packet to the sixth VDH **416** via the link **430**. The sixth VDH **416** can send copies of the data packet to devices within its region or sub-region and send the data packet to the fifth VDH **414** via a next link **428** along the primary path **470**.

Thus, a single copy of the data packet can be propagated through the VDHs **406**-**416** via the enabled primary network paths **434** and **470**-**478**.

In a particular embodiment, a link between two VDHs can fail. For example, the link **424** between the fourth VDH **412** and the third VDH **410** can fail. The fourth VDH **412** can detect the link failure and determine that the primary network path **474** cannot be used to route the data packet to the third VDH **410**. The fourth VDH **412** can determine, based on data stored at the fourth VDH **412**, that a backup network path **468** that does not include the failed link **424** will be used to send the data packet to the third VDH **410**. The data stored at the fourth VDH **412** can indicate that the backup network path **468** is a pre-defined alternate to the primary network path **478**. There may be another backup network path pre-defined along the first network ring, but it is disabled due to the first VHE **402** node failure. Hence, the fourth VDH **412** may determine that the only available backup path in this embodiment would be the backup network path **468**.

In an illustrative embodiment, each of the links **418**-**432** can include a downstream fiber cable that carries data traffic from one or more of the VHEs **402**-**404** to each of the VDHs **406**-**416** via the primary network paths **434** and **470**-**478**, and an upstream fiber cable that carries data traffic from the VDHs **406**-**416** to one or more of the VHEs **402**-**404**. In the embodiment shown, downstream traffic originating at the second VHE **404** can be transmitted via the fiber cables in a counter-clockwise direction. In a particular embodiment, the upstream and downstream fiber cables of each physical link can be re-designated. In the embodiment illustrated in FIG. **4**, the network paths **460**-**468** need not be reversed (i.e., which is used in the absence of a failed link and which is used to re-route data packets when a link fails) due to the node failure at the first VHE **402**.

In another example, a link **456** between the seventh VDH **438** and the eighth VDH **440** can fail. The seventh VDH **438** can detect the link failure and determine that the primary network path **461** cannot be used to route the data packet to the eighth VDH **440**. The seventh VDH **438** can determine, based on data stored at the seventh VDH **438**, that a backup network path **462** that does not include the failed link **456** will be used to send the data packet to the eighth VDH **440**. The data stored at the seventh VDH **438** can indicate that the backup network path **462** is a pre-defined alternate to the primary network path **461** and flows in a direction opposite to the direction of the primary network path **461**. In an illustrative embodiment, the primary network path **461** can include a downstream fiber cable of the failed link **456**, whereas the backup network path **462** can include an upstream fiber cable of the link **454** and can include link **453** of the double link between the second VDH **408** and the third VDH **410**.

In another example, a link **458** between the ninth VDH **442** and the tenth VDH **444** can fail. The ninth VDH **442** can detect the link failure and determine that the primary network path **465** cannot be used to route the data packet to the tenth VDH **444**. The ninth VDH **442** can determine, based on data stored at the ninth VDH **442**, that a backup network path **466** that does not include the failed link **458** will be used to send the data packet to the tenth VDH **444**. The data stored at the ninth VDH **442** can indicate that the backup network path **466** is a pre-defined alternate to the primary network path **465** and flows in a direction opposite to the direction of the primary network path **465**. In an illustrative embodiment, the primary network path **465** can include a downstream fiber cable of the failed link **458**, whereas the backup network path **466** can include an upstream fiber cable of the link **457**.

With respect to the foregoing, the terms "first," "second," etc., are used for convenience of explanation and are not intended to convey a necessary sequence of events or to designate only a referenced element, such as a particular link, VHE or VDH. For example, "first" and "second" links could be relative to a particular VDH, such that any VDH receives data via a first link and sends data via a second link. In addition, the network paths used to transmit data in the absence of link failures and the paths used to re-route data are provided only for illustration and not to demonstrate that data must move downstream in a particular direction (such as clockwise about a network ring) or that data must move upstream in a particular direction (such as counterclockwise about a network ring). Further, data traffic can include video content, voice content, data content, or any combination thereof, and can be communicated to any suitable distribution hubs from video head-ends of an IPTV system or other triple-play or quad-play system.

Referring to FIG. **5**, a particular illustrative embodiment of a method of providing communications services is illustrated. At block **500**, a first video distribution hub of a network ring receives a data packet via a primary network path. In an illustrative embodiment, the data packet can be received from a video head-end or can be a copy of a data packet sent by the video head-end to a prior video distribution hub coupled to the first video distribution hub. The first video distribution hub can receive the data packet via a first link.

Moving to decision step **502**, the first video distribution hub can determine whether a link to a next video distribution hub has failed. The next video distribution hub can be a video distribution hub of the same ring as the first video distribution hub. Alternatively, the next video distribution hub can be a video distribution hub of an overlapping ring in a cascaded ring topology.

If the first video distribution hub determines that there is not a link failure, the method continues to block **504**, and the first video distribution hub sends the data packet, or a copy thereof, to the next video distribution hub via a primary path. On the other hand, if the first video distribution hub determines that there is a failure of a link between the first video distribution hub and the next video distribution hub, the method proceeds to block **506**, and the first video distribution hub determines a backup network path to send the data packet, or a copy thereof, to the next video distribution hub, based on data stored at the first video distribution hub. In a particular embodiment, the first video distribution hub can select a backup network path from a plurality of potential backup network paths based on link cost, a number of hops (i.e., between pairs of nodes), traffic volume, bandwidth availability, type of data packet, other IP routing factors, or any combination thereof. Moving to block **508**, the first video distribution hub sends the data packet, or a copy thereof, to the next video distribution hub via the backup network path. The method terminates at **510**.

Referring to FIG. **6**, an illustrative embodiment of a general computer system is shown and is designated **600**. The computer system **600** can include a set of instructions that can be executed to cause the computer system **600** to perform any one or more of the methods or computer based functions disclosed herein. The computer system **600**, or any portion thereof, may operate as a standalone device or may be connected, e.g., using a network, to other computer systems or peripheral devices, including systems or devices of a video head-end, video distribution hub, IP router, or any combination thereof, as illustrated in FIGS. **1**-**4**.

In a networked deployment, the computer system may operate in the capacity of a video head end system or device, a video distribution hub system or device, or other device. The computer system **600** can also be implemented as or incorporated into various user communication devices, such as a personal computer (PC), a tablet PC, a set-top box (STB), a personal digital assistant (PDA), a mobile device, a palmtop computer, a laptop computer, a desktop computer, a communications device, a wireless telephone, a land-line telephone, a control system, a camera, a scanner, a facsimile machine, a printer, a pager, a personal trusted device, a web appliance, a network router, switch or bridge, or any other machine capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that machine. In a particular embodiment, the computer system **600** can be implemented using electronic devices that provide voice, video or data communication. Further, while a single computer system **600** is illustrated, the term "system" shall also be taken to include any collection of systems or sub-systems that individually or jointly execute a set, or multiple sets, of instructions to perform one or more computer functions.

As illustrated in FIG. **6**, the computer system **600** may include a processor **602**, e.g., a central processing unit (CPU), a graphics-processing unit (GPU), or both. Moreover, the computer system **600** can include a main memory **604** and a static memory **606** that can communicate with each other via a bus **608**. As shown, the computer system **600** may further include a video display unit **610**, such as a liquid crystal display (LCD), an organic light emitting diode (OLED), a flat panel display, a solid state display, or a cathode ray tube (CRT). Additionally, the computer system **600** may include an input device **612**, such as a keyboard, and a cursor control device **614**, such as a mouse. The computer system **600** can also include a disk drive unit **616**, a signal generation device **618**, such as a speaker or remote control, and a network interface device **620**.

In a particular embodiment, as depicted in FIG. **6**, the disk drive unit **616** may include a computer-readable medium **622** in which one or more sets of instructions **624**, e.g. software, can be embedded. Further, the instructions **624** may embody one or more of the methods or logic as described herein. In a particular embodiment, the instructions **624** may reside completely, or at least partially, within the main memory **604**, the static memory **606**, and/or within the processor **602** during execution by the computer system **600**. The main memory **604** and the processor **602** also may include computer-readable media.

In an alternative embodiment, dedicated hardware implementations, such as application specific integrated circuits, programmable logic arrays and other hardware devices, can be constructed to implement one or more of the methods described herein. Applications that may include the apparatus and systems of various embodiments can broadly include a variety of electronic and computer systems. One or more embodiments described herein may implement functions using two or more specific interconnected hardware modules or devices with related control and data signals that can be communicated between and through the modules, or as portions of an application-specific integrated circuit. Accordingly, the present system encompasses software, firmware, and hardware implementations.

In accordance with various embodiments of the present disclosure, the methods described herein may be implemented by software programs executable by a computer system. Further, in an exemplary, non-limited embodiment, implementations can include distributed processing, component/object distributed processing, and parallel processing. Alternatively, virtual computer system processing can be constructed to implement one or more of the methods or functionality as described herein.

The present disclosure contemplates a computer-readable medium that includes instructions **624** or receives and executes instructions **624** responsive to a propagated signal, so that a device connected to a network **626** can communicate voice, video or data over the network **626**. Further, the instructions **624** may be transmitted or received over the network **626** via the network interface device **620**.

While the computer-readable medium is shown to be a single medium, the term "computer-readable medium" includes a single medium or multiple media, such as a centralized or distributed database, and/or associated caches and servers that store one or more sets of instructions. The term "computer-readable medium" shall also include any medium that is capable of storing, encoding or carrying a set of instructions for execution by a processor or that cause a computer system to perform any one or more of the methods or operations disclosed herein.

In a particular non-limiting, exemplary embodiment, the computer-readable medium can include a solid-state memory such as a memory card or other package that houses one or more non-volatile read-only memories. Further, the computer-readable medium can be a random access memory or other volatile re-writable memory. Additionally, the computer-readable medium can include a magneto-optical or optical medium, such as a disk or tapes or other storage device to capture carrier wave signals such as a signal communicated over a transmission medium. A digital file attachment to an e-mail or other self-contained information archive or set of archives may be considered a distribution medium that is equivalent to a tangible storage medium. Accordingly, the disclosure is considered to include any one or more of a computer-readable medium or a distribution medium and other equivalents and successor media, in which data or instructions may be stored.

In accordance with various embodiments, the methods described herein may be implemented as one or more software programs running on a computer processor. Dedicated hardware implementations including, but not limited to, application specific integrated circuits, programmable logic arrays and other hardware devices can likewise be constructed to implement the methods described herein. Furthermore, alternative software implementations including, but not limited to, distributed processing or component/object distributed processing, parallel processing, or virtual machine processing can also be constructed to implement the methods described herein.

It should also be noted that software that implements the disclosed methods may optionally be stored on a tangible storage medium, such as: a magnetic medium, such as a disk or tape; a magneto-optical or optical medium, such as a disk; or a solid state medium, such as a memory card or other package that houses one or more read-only (non-volatile) memories, random access memories, or other re-writable (volatile) memories. The software may also utilize a signal containing computer instructions. A digital file attachment to e-mail or other self-contained information archive or set of archives is considered a distribution medium equivalent to a tangible storage medium. Accordingly, the disclosure is considered to include a tangible storage medium or distribution medium as listed herein, and other equivalents and successor media, in which the software implementations herein may be stored.

Although the present specification describes components and functions that may be implemented in particular embodiments with reference to particular standards and protocols, the invention is not limited to such standards and protocols. For example, standards for Internet and other packet switched network transmission (e.g., TCP/IP, UDP/IP, HTML, HTTP) represent examples of the state of the art. Such standards are periodically superseded by faster or more efficient equivalents having essentially the same functions. Accordingly, replacement standards and protocols having the same or similar functions as those disclosed herein are considered equivalents thereof.

The illustrations of the embodiments described herein are intended to provide a general understanding of the structure of the various embodiments. The illustrations are not intended to serve as a complete description of all of the elements and features of apparatus and systems that utilize the structures or methods described herein. Many other embodiments may be apparent to those of skill in the art upon reviewing the disclosure. Other embodiments may be utilized and derived from the disclosure, such that structural and logical substitutions and changes may be made without departing from the scope of the disclosure. Additionally, the illustrations are merely representational and may not be drawn to scale. Certain proportions within the illustrations may be exaggerated, while other proportions may be minimized. Accordingly, the disclosure and the figures are to be regarded as illustrative rather than restrictive.

One or more embodiments of the disclosure may be referred to herein, individually and/or collectively, by the term "invention" merely for convenience and without intending to voluntarily limit the scope of this application to any particular invention or inventive concept. Moreover, although specific embodiments have been illustrated and described herein, it should be appreciated that any subsequent arrangement designed to achieve the same or similar purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all subsequent adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the description.

The Abstract of the Disclosure is provided to comply with 37 C.F.R. §1.72(b) and is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, various features may be grouped together or described in a single embodiment for the purpose of streamlining the disclosure. This disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter may be directed to less than all of the features of any of the disclosed embodiments. Thus, the following claims are incorporated into the Detailed Description, with each claim standing on its own as defining separately claimed subject matter.

The above-disclosed subject matter is to be considered illustrative, and not restrictive, and the appended claims are intended to cover all such modifications, enhancements, and other embodiments, which fall within the true spirit and scope of the present invention. Thus, to the maximum extent allowed by law, the scope of the present invention is to be determined by the broadest permissible interpretation of the following claims and their equivalents, and shall not be restricted or limited by the foregoing detailed description.

What is claimed is:

1. A system to distribute digital content, the system comprising:

a first network ring comprising a first video distribution hub and a second video distribution hub, wherein the first video distribution hub is coupled to a first link and to a second link, wherein the first video distribution hub and the second video distribution hub are associated with a first network ring, a second network ring, and a third network ring of a cascaded network ring architecture, the first video distribution hub adapted to:

when the second link is intact, send a data packet, or a copy of the data packet, from the first video distribution hub to the second video distribution hub via a primary network path that includes the second link and that excludes the first link; and

when the second link has failed, send the data packet, or the copy of the data packet, from the first video distribution hub to the second video distribution hub via a backup network path that includes the first link and that does not include the second link, wherein the backup network path is selected from one of a primary backup network path, a secondary backup network path, and a tertiary backup network path based on one or more selection factors, wherein the primary backup network path includes a first plurality of nodes of the first network ring, the secondary backup network path includes a second plurality of nodes of the second network ring, the tertiary backup network path includes a third plurality of nodes of the third network ring, and wherein at least one node of the first plurality of nodes differs from each of the second plurality of nodes and at least one node of the third plurality of nodes differs from each node of the first plurality of nodes and differs from each node of the second plurality of nodes.

2. A network comprising:

a first video distribution hub and a second video distribution hub, wherein the first video distribution hub is coupled to a first link and a second link, wherein the first video distribution hub and the second video distribution hub are associated with a first network ring, a second network ring, and a third network ring of a cascaded network ring architecture; and

path selection logic configured to select a backup network path from one of a primary backup network path, a secondary backup network path, and a tertiary backup path based on one or more selection factors, wherein the primary backup path includes a first plurality of nodes of the first network ring, wherein the secondary backup network path includes a second plurality of nodes of the second network ring, wherein the tertiary backup path includes a third plurality of nodes of the third network ring, and wherein at least one node of the first plurality of nodes is different from each of the second plurality of nodes and at least one node of the third plurality of nodes differs from each node of the first plurality of nodes and differs from each node of the second plurality of nodes, wherein:

when the first link is intact, a data packet or a copy of the data packet is routed from the first video distribution hub to the second video distribution hub via a primary network path that includes the first link; and

when the first link has failed, the data packet or the copy of the data packet is routed from the first video distribution hub to the second video distribution hub via the selected backup network path, wherein the selected backup network path includes the second link but does not include the first link.

3. The network of claim **2**, wherein the plurality of nodes includes a video head-end associated with the first network ring, and wherein a single copy of the data packet is propagated from the video head-end to each video distribution hub of the first network ring.

4. The network of claim **2**, wherein the data packet includes multicast video content, and wherein the routing the data packet via the selected backup network path results in a recovery time of approximately fifty milliseconds (50 ms).

5. The system of claim **1**, wherein the one or more selection factors include at least a data traffic volume associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

6. The system of claim **1**, wherein the one or more selection factors include at least an available bandwidth associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

7. The system of claim **1**, wherein the one or more selection factors include at least a link cost associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

8. The system of claim **1**, wherein the one or more selection factors include at least a number of hops between nodes associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

9. The system of claim **1**, wherein the one or more selection factors include at least a transmission speed associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

10. The network of claim **2**, wherein the one or more selection factors include at least a data traffic volume associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

11. The network of claim **2**, wherein the one or more selection factors include at least an available bandwidth associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

12. The network of claim **2**, wherein the one or more selection factors include at least a link cost associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

13. The network of claim **2**, wherein the one or more selection factors include at least a number of hops between nodes associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

14. The network of claim **2**, wherein the one or more selection factors include at least a transmission speed associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

15. A method comprising:

sending a data packet, or a copy of the data packet, from a first video distribution hub to a second video distribution hub, wherein the first video distribution hub is coupled to a first link and to a second link, wherein the first video distribution hub and the second video distribution hub are associated with a first network ring, a second network ring, and a third network ring of a cascaded network ring architecture, wherein sending comprises:

when the second link is intact, sending the data packet, or the copy of the data packet, from the first video distribution hub to the second video distribution hub via a primary network path that includes the second link and excludes the first link; and

when the second link has failed, sending the data packet, or the copy of the data packet, from the first video distribution hub to the second video distribution hub via a backup network path that includes the first link and that does not include the second link, wherein the backup network path is selected from one of a primary backup network path, a secondary backup network path, and a tertiary backup path based on one or more selection factors;

wherein the primary backup network path includes a first plurality of nodes of the first network ring;

wherein the secondary backup network path includes a second plurality of nodes of the second network ring;

wherein the tertiary backup path includes a third plurality of nodes of the third network ring; and

wherein at least one node of the first plurality of nodes differs from each of the second plurality of nodes and at least one node of the third plurality of nodes differs from each node of the first plurality of nodes and differs from each node of the second plurality of nodes.

16. The method of claim **15**, wherein the one or more selection factors includes at least a data traffic volume associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

17. The method of claim **15**, wherein the one or more selection factors includes at least an available bandwidth associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

18. The method of claim **15**, wherein the one or more selection factors includes at least a link cost associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

19. The method of claim **15**, wherein the one or more selection factors includes at least a number of hops between nodes associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

20. The method of claim **15**, wherein the one or more selection factors includes at least a transmission speed associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

21. The method of claim **15**, wherein the one or more selection factors includes at least a data traffic volume associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

22. The method of claim **15**, wherein the one or more selection factors includes at least an available bandwidth associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

23. The method of claim **15**, wherein the one or more selection factors includes at least a link cost associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

24. The method of claim **15**, wherein the one or more selection factors includes at least a number of hops between nodes associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

25. The method of claim **15**, wherein the one or more selection factors includes at least a transmission speed associated with each of the primary backup network path, the secondary backup network path, and the tertiary backup path.

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